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Effect of Consumer Knowledge on Energy Consumption Behavior

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Final Report - IE 422 - Senior Design Spring 2011

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EXECUTIVE SUMMARY

EPRI would like to increase their understanding of consumer energy usage habits. By providing survey participants with these devices, they intend to see at what point the knowledge of energy prices per device causes a change of usage habits. The Industrial Engineering senior design team at the University of Tennessee has been asked to develop a project based on these expectations to distribute, test, and gather findings on this information. Given the limited amount of time and resources, the team has developed an analysis of usage for a small sample size of households to develop a baseline cost for many types of devices found within a typical home. The team has also has surveyed willing participants on their work and home energy conservation habits and prepared an analysis based on these results.

Individual future usage based on each energy-using device can be predicted with relatively high accuracy, reaching up to 0.999 and 0.997 R^2 values for the refrigerators included in the study. This allows for a very accurate prediction of future values for each of these devices. The same can be said for individual computer usage as well, with values of R^2 ranging from 0.981 to 0.991. Other devices, when grouped together by device type, exhibit a larger range of accuracy for future predictions. This can be seen in the use of small appliances such as toaster ovens, which vary more significantly because of their variable usage. Since computers, television entertainment systems, and other electronics contribute to the majority of the electricity bill, it can be concluded from this study how much participants are willing to pay knowing the price for each device over a specified time frame. Usage habits and trends of college aged and young adults can be interpreted from the previous statement, with these groups having a heavy reliance on technology.

Surveys, using a sample size of sixty, sent out to analyze usage habits of individuals at both at work and home returned interesting results. Most of those who completed the work survey said they left their computers on all day, charge electronics, and do not try to conserve energy. A theory behind this is that the previously mentioned practices may be related to convenience. Home surveys showed that many homeowners would be more likely to read their utility bills if they showed more in-depth information. Similar to the work survey, many people surveyed said they left their computers on during the day. Though most said they turned off lights while at home, less than half of those surveyed claimed they try to conserve at home. Participants also agreed they would be much more conscious of their energy usage if they had devices which told them how much certain devices were costing them.

Based on the data gathered for energy devices and from surveys, there are a variety of options for continuing forth with more in-depth studies on usage habits. It is our recommendation that further research be conducted pertaining to the use of energy monitoring devices, particularly over a larger sample size as to more accurately quantify results. Surveying more participants on the features they would like to see in utility bills is also recommended.

TABLE OF CONTENTS

INTRODUCTION

Our undergraduate research project is a continuation of a previous project that was completed in the fall 2009 and spring 2010 semesters by a group of University of Tennessee students led by Taylor Mann and Michael Vanderlan. Like us, they were partially sponsored by the Electric Power Research Institute (EPRI). Their initial study involved creating a report to document the energy consumption behavior of individuals by providing them with a variety of different home monitoring devices with which to measure their day-to-day usage of electricity. Whereas the preliminary study was focused on finding affordable and user-friendly devices for monitoring home usage, this new continuation will be used to provide usage data for standard devices found within a home to quantify the amount of money spent on the operation these devices. This will allow for a comparison of energy usage for a variety of devices as well as provide monthly and yearly usage data for a variety of different home appliances and other various devices. With the data collected, the intention is to be able to provide detailed home usage costs for common appliances and other energy-using devices. This will be used to determine at what point the knowledge of energy costs makes a difference in energy conservation habits.

As a supplement to this study, our group will also be combining survey data taken on the energy usage habits of individuals within their homes, as well as in their work environment. The main goal of this survey is to exhibit the differences of habits in their respective environments, and also to show how the knowledge of work-time usage can contribute to overall energy savings within the workplace.

MONITORING DEVICES

Devices used to monitor energy usage were selected based on a variety of criteria, including price, availability, ease of setup, and ease of use. They were also chosen based on their use in the previous year's device selection criteria. This left us with the selection of the Kill a Watt EZ, Black and Decker, Watts Up Pro, and T.E.D.(The Electronic Device). Because of the installation difficulty and professional setup costs of the T.E.D., this device was immediately removed from the study. Concerns were also expressed with Black and Decker devices because of the necessity to set up and leave the device unattended connected to a power meter. With most study participants living within the college campus community, access to personal meters is not probable or possible. This device could not be used for most survey participants, because of their living situations, but one was included in the study to give a basis of entire house usage in conjunction with single components.

The devices used within this study are the Kill a Watt EZ, Black and Decker, and Watts Up Pro. These devices were gathered and given in sets to each willing participant. They are to be installed by the participant and set to a cost of $0.0875/kWh. Sets were comprised of:

- 3 Kill a Watt EZ
- 1 Watts Up Pro
- 1 Black and Decker

Since Kill a Watt EZs are bulky and would take up an entire outlet, each comes with a short 1 foot long extension cord to allow for other devices to also be plugged into the same outlet. Although Black and Decker devices could not be utilized for many participants, they were still included within each kit as it was a possibility for some. Instructions for each device were also included in each kit so that participants would be informed on how to properly use each device and could take valid data readings throughout the study. They helped the participants with the calibration of each device, setup instructions, and resetting the devices from the previous study.

A total of 5 kits were distributed to willing volunteers. After receiving their allocated set of devices, participants were given a spreadsheet detailing which types of appliances to use for each device as well as recording instructions. If a device of each type could not be used, participants were asked to record data for a similar type of device within their home and make a note of this change on their blank data recording sheet. A blank copy of this sheet can be found in **Table 1**, and filled in copies for each device can be found in **Tables 2-6** of the appendix. Also, **Graphs 9-13** show these values for each set of computers, appliances, lamps, televisions, and the Black and Decker device respectively. It was asked of each participant to record readings twice daily for a two week span at a predetermined time each day. This provides 30 data points for each individual device providing a sufficient amount of time to create linear regression models to predict future usage for each monitored device. Also, this data could be grouped together based on device type to provide an accurate representation of the monthly and yearly usage of the specified devices. This will prove beneficial when determining the cost of usage of having multiple devices of the same type, i.e. multiple computers or televisions.

DEVICE DATA ANALYSIS

One potentially helpful use for data collection is forecasting future data by establishing a trend. During the data collection stage of our project, we collected 540 data points; 150 points for computers, 150 points for kitchen appliances, 150 points for televisions, 60 points for lamps, and 30 points for the Black and Decker meter reading. With these data points placed into scatter plots for each category, we were able to plot a trend line for each data set. The equation of each trend line allowed us to predict the cost of certain items in our homes as if it was monitored for a year, or any other amount of time a person might be interested in. Below are the trend line equations for each individual item that was monitored. Also, we regrouped similar items to get an averaged trend line. Those trend line equations are also show below. Additionally, the coefficient of determination, R^2, for each trend line is given. The closer the R^2 value is to one, the more accurate prediction it gives. The value in the fourth column of the summary tables is the estimated yearly cost. This cost was estimated by plugging in 365 days for x in each equation. Implementing cost prediction encourages people to use less energy because they will see the bigger cost of their usages instead of a seemingly insignificant amount. Furthermore, if these yearly values were rolled up into one total cost, better results with energy consumption could occur.

Individual Usage and Trends

Data Type	Trend Line Equation	Coefficient of Determination	Yearly Cost- 365 days
Computers:			
Computer 1 (Laptop)	y = 0.023x	$R^2 = 0.989$	$8.40 per year
Computer 2 (Laptop)	y = 0.064x	$R^2 = 0.981$	$23.36 per year
Computer 3 (Laptop)	y = 0.049x	$R^2 = 0.990$	$17.89 per year
Computer 4 (Desktop)	y = 0.239x	$R^2 = 0.991$	$87.24 per year
Computer 5 (Desktop)	y = 0.295x	$R^2 = 0.975$	$107.68 per year
Appliances:			
Microwave	y = 0.010x	$R^2 = 0.981$	$3.65 per year
Toaster	y = 0.012x	$R^2 = 0.988$	$4.38 per year
Toaster Oven	y = 0.079x	$R^2 = 0.823$	$28.84 per year
Refrigerator 1	y = 0.285x	$R^2 = 0.999$	$104.03 per year
Refrigerator 2	y = 0.556x	$R^2 = 0.997$	$202.94 per year
TV/Stereo:			
TV 1	y = 0.030x	$R^2 = 0.961$	$10.95 per year
TV 2	y = 0.030x	$R^2 = 0.991$	$10.95 per year
TV 3	y = 0.293x	$R^2 = 0.987$	$106.95 per year
TV & Stereo	y = 0.178x	$R^2 = 0.986$	$64.97 per year
Stereo	y = 0.024x	$R^2 = 0.928$	$8.76 per year
BD Meter Reading:	y = 1.925x	$R^2 = 0.991$	$702.63 per year

The charts for each of these values can be found in **Graphs 1-4** of the Appendix. These graphs show the actual usage with fitted regression lines for single lamp conditions. The readings for the single Black and Decker entire home usage can be found in **Graph 5.**

The benefit of regrouping similar data is that a better and more general estimate can be made and presented to homeowners. The more similar items that are monitored and plotted together, the more accurate the average trend line would be to apply to those types of equipment. So, we decided to create more trend lines to determine a more realistic and general equation that may be useful in estimates.

On the other hand, grouping items together and averaging the trends lessens accuracy for each individual item. The cost may be more or less depending on the variation of costs for the items being averaged together. An average cost list such as the one presented below may be more useful for distributing to homeowners as a generalized estimation chart.

Overall Usage and Trends Grouped by Device Type

Data Type	Trend Line Equation	Coefficient of Determination	Yearly Cost- 365 days
Computers:			
Laptops	y = 0.045x	$R^2 = 0.629$	$16.43 per year
Desktops	y = 0.267x	$R^2 = 0.946$	$97.46 per year
TVs:	y = 0.030x	$R^2 = 0.976$	$10.95 per year
Refrigerators:	y = 0.420x	$R^2 = 0.724$	$153.30 per year
Smaller Appliances:	y = 0.011x	$R^2 = 0.957$	$4.02 per year
TV/Stereo Systems:	y = 0.236x	$R^2 = 0.808$	$86.14 per year
Lamps:			
Fluorescent Bulb	y = 0.005x	$R^2 = 0.976$	$1.83 per year
Incandescent Bulb	y = 0.013x	$R^2 = 0.900$	$4.75 per year

Data combined by device type can be found for televisions, appliances, and computers in **Graphs 6-8** respectively of the Appendix.

Along with collected data for common items in a home, two lamps were monitored using different types of bulbs. The first lamp used an energy-efficient fluorescent bulb and the second lamp used a regular incandescent bulb. After plotting the data and attaining a trend line, we were able to show exactly how much money the user of the first lamp saved by using an energy-efficient device. If monitored for a year, the energy-efficient lamp would save a person $2.92 per year. While that may seem like a small amount, most homes use several bulbs which would increase the savings dramatically. Comparisons such as this could also encourage further reductions in energy consumptions since people are more likely to change their behavior if they are presented with valid evidence that doing so would save them money.

DECISION SUPPORT TOOL

With the data collected and trend lines created, a decision support tool was made. This tool enables a consumer to see what the total costs will be for different quantities of each of these items over a desired time period. By inputting the number of days, the cost per kilowatt-hour, the number of each device into the yellow boxes, we are able to give an estimated cost for the desired time period which can be seen in the blue box. The cost that is shown is assuming a cost of $0.0875/kWh, so if the cost per kilowatt-hour were to change, the value in the support tool would need to be changed as well. The cost for each device was calculated by creating a new trend line for kilowatt-hours for each device as opposed to price like done before. This support tool can help consumers see how much their energy consumption may cost them over a certain number of days. If they see a large number in the total cost box, it may help them decide to change their behavior in order to save money.

Number of Days	30
$/kWh	$0.0875

Devices	Number in Household	Cost
Only TV (no DVD, etc)	2	$1.84
TV + DVD, sound system	2	$14.90
Stereo	1	$0.73
Lamps	4	$1.09
Refrigerator	1	$12.62
Microwave	1	$0.33
Toaster	1	$1.46
Laptop	1	$1.40
Desktop	2	$16.91
	Total Cost	**$51.27**

DEVICE CONCLUSIONS AND RECOMMENDATIONS

From the results, we can conclude with a high level of confidence the yearly costs for each specific appliance tested during the study. The lowest R^2 values come from devices which are used on an inconsistent basis, such as one of the toaster ovens. Even from this value of .823 we can still predict with rather high certainty the yearly usage range for this appliance. Refrigerators, which represent appliances and are always on, use the most energy per year with an average of $153.30. Desktop computers which are always on such as the two in this study also contribute substantially to electricity bills with an average cost of the two being $97.46. With significantly less usage, laptops are found to not significantly affect overall billing, but

depending on their usage can cost as much as $23.36 a year. Television and entertainment centers also contribute to a large portion of each bill with an average of $86.14 per year, depending on the size and frequency of use.

The results of this survey are based on a relatively small sample size, due to the restrictions of number of willing participants as well as the total number of energy monitoring devices. Ideally there would be a large enough sample size from each device to be able to calculate monthly or yearly data for each kind of appliance with a high level of confidence. Instead we are left with a wide range of values for each appliance set, which still gives us a good idea of overall usage and costs, but does not take into account the wide range of products available.

To improve the results and accuracy of this study, many more devices would need to be used to record data over a longer period of time to more accurately determine average usage habits. Demographics would also need to be gathered on all survey participants and compared to those of the overall area as to get a good representation of each group involved in the study. Since we were restricted to mostly apartment owners for this study, it could be repeated as a separate study to more accurately determine the usage habits of students as opposed to those of older age ranges. Since students make up such a substantial population in and around the campus area, this study can be used to quantify the amount students are willing to pay for activities which require the usage of energy.

SURVEY ANALYSIS

During the research stage, surveys were conducted in a work and home environment. The purpose of conducting the surveys was to better understand tendencies with energy usage in the work and home environments. There were sixty participants, n=60, for each survey. By applying the equation $\bar{x} \pm z_c \sqrt{p(p-1)/n}$ we can find the confidence intervals of the survey's answers. The value of x-bar and p is the proportion of an answer for a particular question; we are going to be looking at a 90% confidence level making z_c equal to 1.65. For example, for the second question of the work survey, 83.33% of respondents answered that they leave their computers on throughout the workday. In this case, x-bar and p is equal to 83.33% and n is equal to 60. Therefore, our confidence interval is 83.33% ± 7.94%. This means that we are 90% confident that 75.39% - 91.27% of people leave their computers on throughout the day. The confidence intervals for survey questions can be found in **Table 7** of the Appendix and a blank copy of the question form can be found in **Figure 1**. The first topic covered in the work survey was computer usage. The majority of people leave their computer on throughout the day. This may be attributed to a convenience factor. The majority of surveyed people work in a position that requires the use of a computer. So, when a person leaves their computer, they are likely to be returning to their computer momentarily. Therefore, turning off their computer throughout the day may be inconvenient. Another question that we wanted answered is if people bring rechargeable items to work for convenience or to save money. Out of the 60 people surveyed, 34

answered that they do charge items at work. On the follow up question, 28 answered that they charge items at work for convenience. It is assumed that the 28 came from the group of 34 that answered they do charge items at work. This means that 82.35% ± 8.12% of the people that charge item at work do so because of convenience. This finding also supports the statement that energy usage is related to convenience.

Home tendencies were also evaluated. One goal was to determine if energy savings are driven by a person's character, i.e. a person practicing energy savings at home will do so at work, or vice-versa. The last question of the home survey was the same wording except for the word "home" replacing the word "work." The results with these two questions were very close. Because of this, we will assume that a person's character and not the environment, work versus home, plays a more significant role in energy-saving tendencies. This is also supported by similar results with the fourth question. The wording of this question reflects that of the third question in the work survey. However, other results and conclusions were made based on other questions in the survey. An interesting finding by the second home survey question is that people responded that they would be affected by having a more detailed utility bill. This seems to imply that with more knowledge, a person is more likely to be more conservative with energy. The seventh question also supports that a person with more knowledge is more likely to save energy. These findings help answer part of the overall question of the project. More knowledge and energy-usage awareness increases the chances of a person to save energy as well as the energy-saving method being convenient.

The results for both of these surveys, home and work usage, can be found in **Graphs 14 and 15** of the Appendix.

SURVEY CONCLUSIONS AND RECOMMENDATIONS

Conducting the surveys allowed conclusions to be made and revealed certain tendencies. These conclusions and tendencies can then be related to the goal of the project, answering what can be done to promote an energy saving mindset. From the surveys, it was concluded that convenience, knowledge, and awareness of energy usage were contributors to whether or not people tended to save energy. The factor of convenience can be seen throughout the surveys. One must assess if the more energy efficient way is convenient. The questions pertained to leaving a computer on throughout the day provided support for concluding that convenience plays a part in conserving energy. The responses favored leaving the computer on throughout the day. Rebooting a computer may take a couple of minutes. Therefore, it is more convenient for a person to leave their computer on throughout the day compared to shutting it off. However, a convenient way, supported by survey results, to save energy can be seen by the responses to questions regarding turning off the lights. Typically, turning off the lights only requires the push of a button or flip of the switch. So, this provides a quick and easy way to conserve energy. In addition to convenience, energy awareness may also contribute to conserving energy. This can be seen in questions primarily in the home survey concerning if more knowledge would promote

energy savings. The responses concurred that if people were given more feedback through means such as a more detailed bill or had real time energy usage, they may be more inclined to conserve energy. In conclusion, the surveys helped determine that convenience, knowledge, and energy usage awareness would contribute to people conserving energy.

There are a variety of factors that weighed into who received the surveys. In many cases they could not be sent out to an entire work facility, so there was heavy reliance on forwarding of survey links within social circles. They were sent out mostly via email but also made available through Facebook and other forms of social networking in an attempt to reach a much larger audience. This could skew results towards the tendencies of young adults and those not working in full time employment because of the typical users of these forms of communication and the limitations of our own networks. This could prove a very beneficial resource if properly utilized for future studies to determine work habits of people in different age ranges. The continued use of this survey is recommended with the goal of addressing a wider audience to increase participation and confidence in results. It is also recommended to further investigate the point at which the costs outweigh the convenience of energy conservation measures. This can be particularly beneficial for companies that are attempting to find ways to conserve more in the workplace.

SUMMARY OF WORK (BY TASK)

- Decide Devices for Use and Project Scope – All Members
- Create Proposal – All Members
- Compile and Deliver Home Monitoring Kits – All Members
- Create Surveys – Lindsey
- Distribute Surveys – All Members
- Monitor Data – All Members
- Compile Sample Data – Lindsey, Sarah, Brianna
- Analysis of Survey Results – Lindsey, Lucas, Stephen
- Analysis of Device Results – Brianna, Sarah
- Conclusions and Recommendations – All Members
- Compile Report Data – All Members
- Executive Summary – All Members

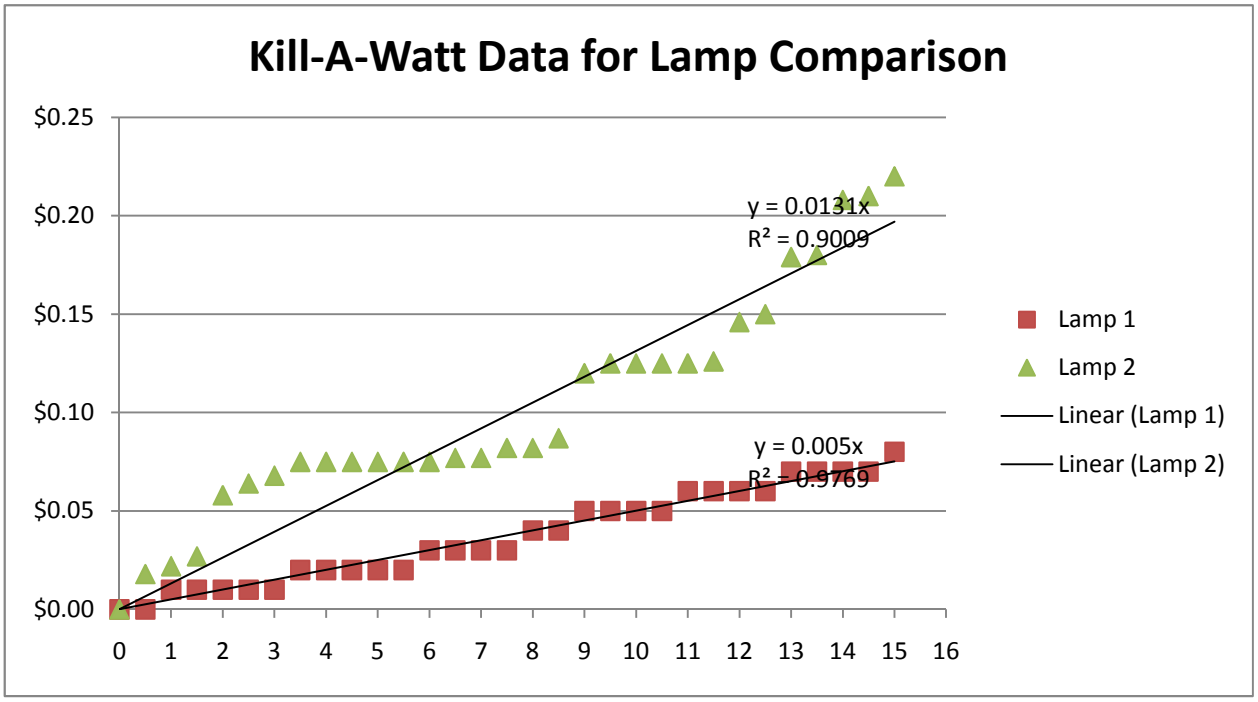
CONCLUSIONS AND LESSONS LEARNED

Overall conclusions based upon this study lean heavily toward the convenience of energy conservations measures within home and work environments. Responses of home environment surveys and energy habits of those who participated in the study show this correlation between conservation and convenience. In order to make an impact on the habits of those involved, a user-friendly interface on a relatively cheap and efficient device would be a necessity. Detailed usage bills would be highly beneficial as a supplement to these devices as to provide the maximum convenience for those involved.

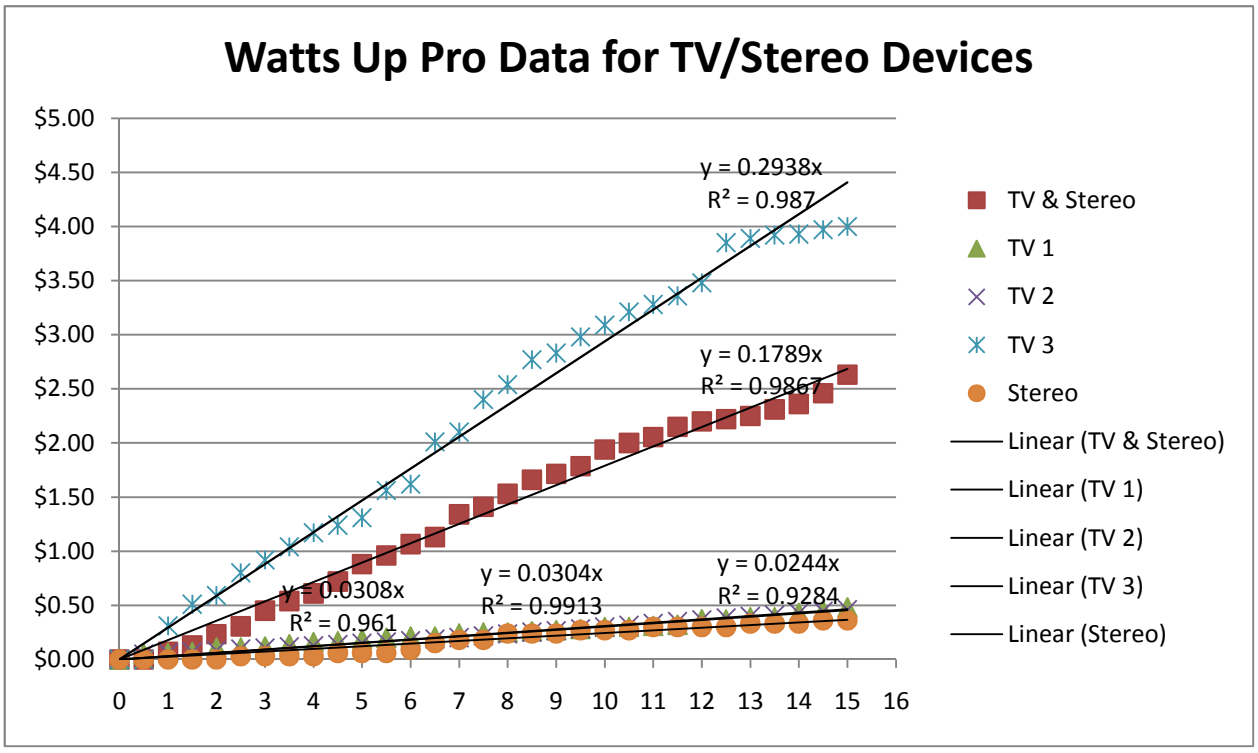
Those involved in the study were not likely to change their usage habits based solely upon the knowledge of a single product's monthly usage. One reason for this is the indirect approach used to determine a predicted monthly and yearly usage which had to be extrapolated from data gathered during the short two week study. A built-in calculator to predict long-term usage for each energy-using device would have a more probable chance of modifying energy usage habits. Also, due young adults' heavy reliance on technology, the usage costs of computers and other forms of electronic entertainment are unlikely to change based on the knowledge of costs of these products.

Along with determining the results of this survey, this study has also provided the senior design team an opportunity to exhibit proficiency in the skills required for graduates of The University of Tennessee Industrial Engineering Department. This has been accomplished throughout the semester with the formulation, execution, and analysis of this project. A sound knowledge of engineering principles has been demonstrated by possessing the ability to analyze and interpret data collected. Overall this project has provided a chance to work together on a team to accomplish the goals of our engineering curriculum, while also providing EPRI with the results of the usage habits of individuals when using energy monitoring device.

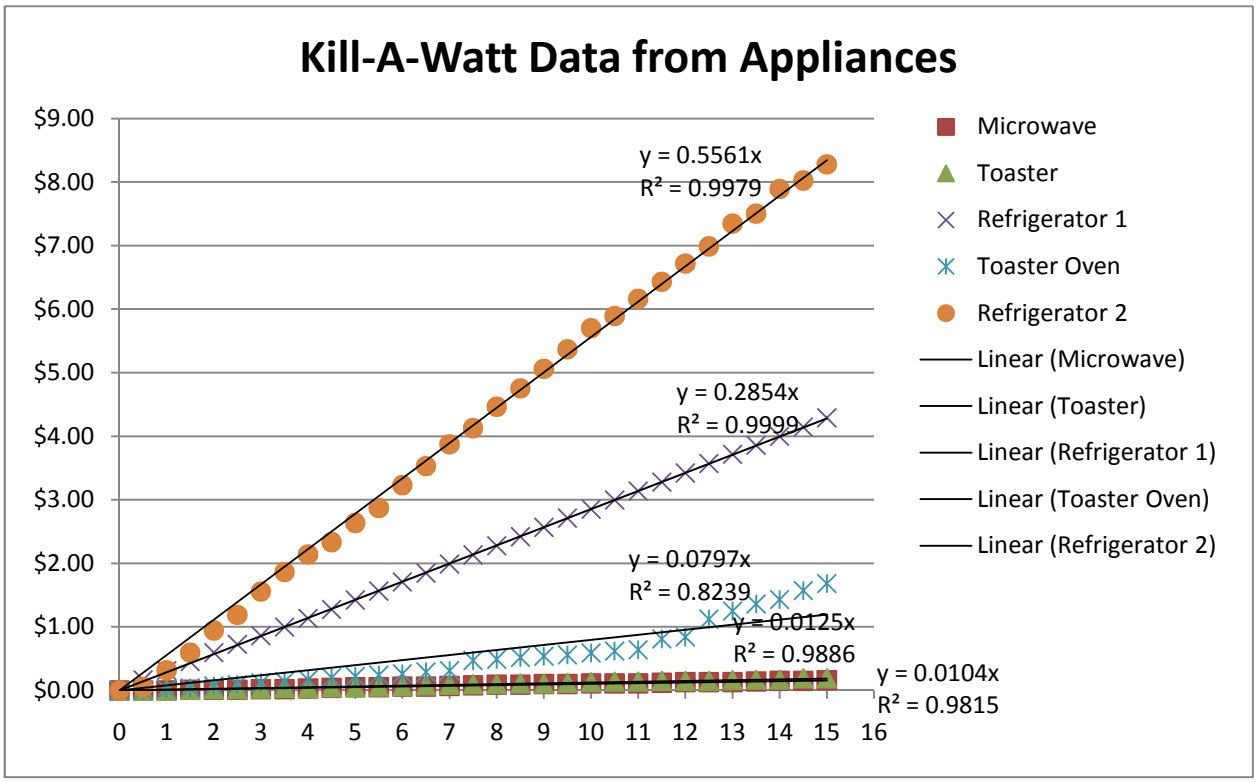
APPENDIX



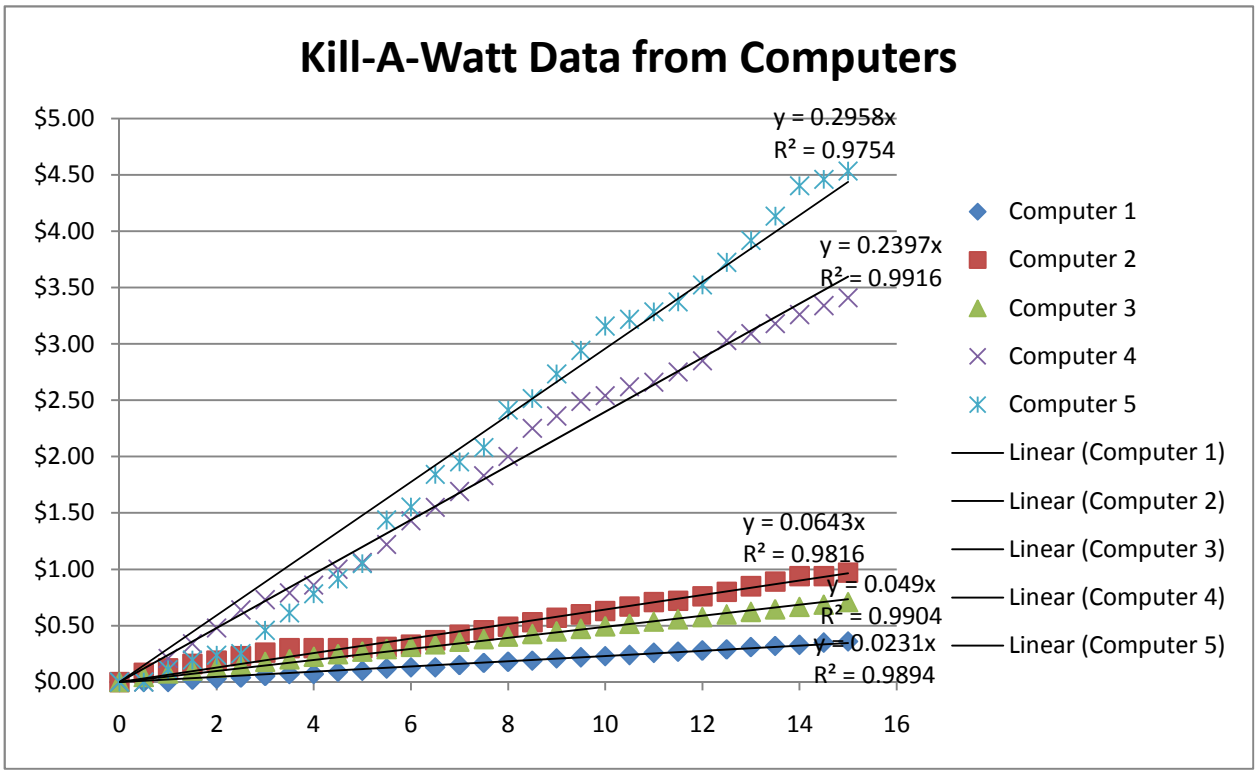
Graph 1: Shows the trendlines for each lamp tested during the study within two households



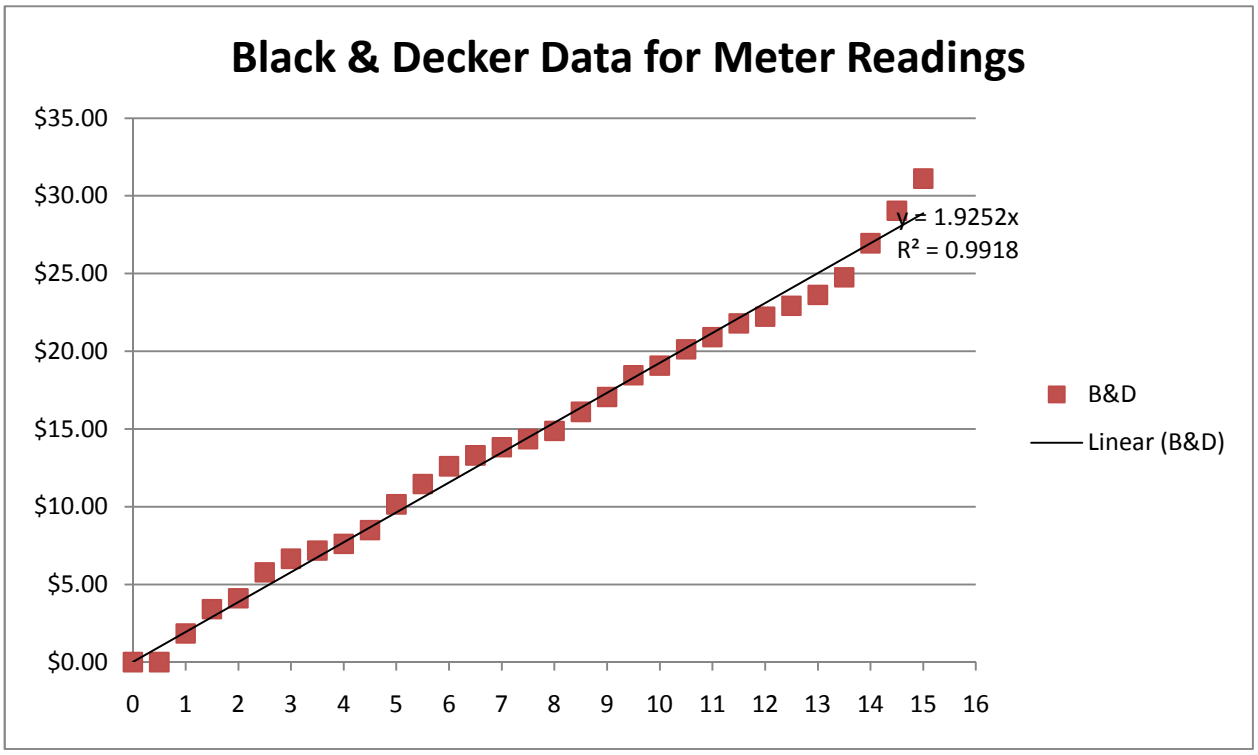
Graph 2: Shows the trendlines for various electronic devices used within the study.



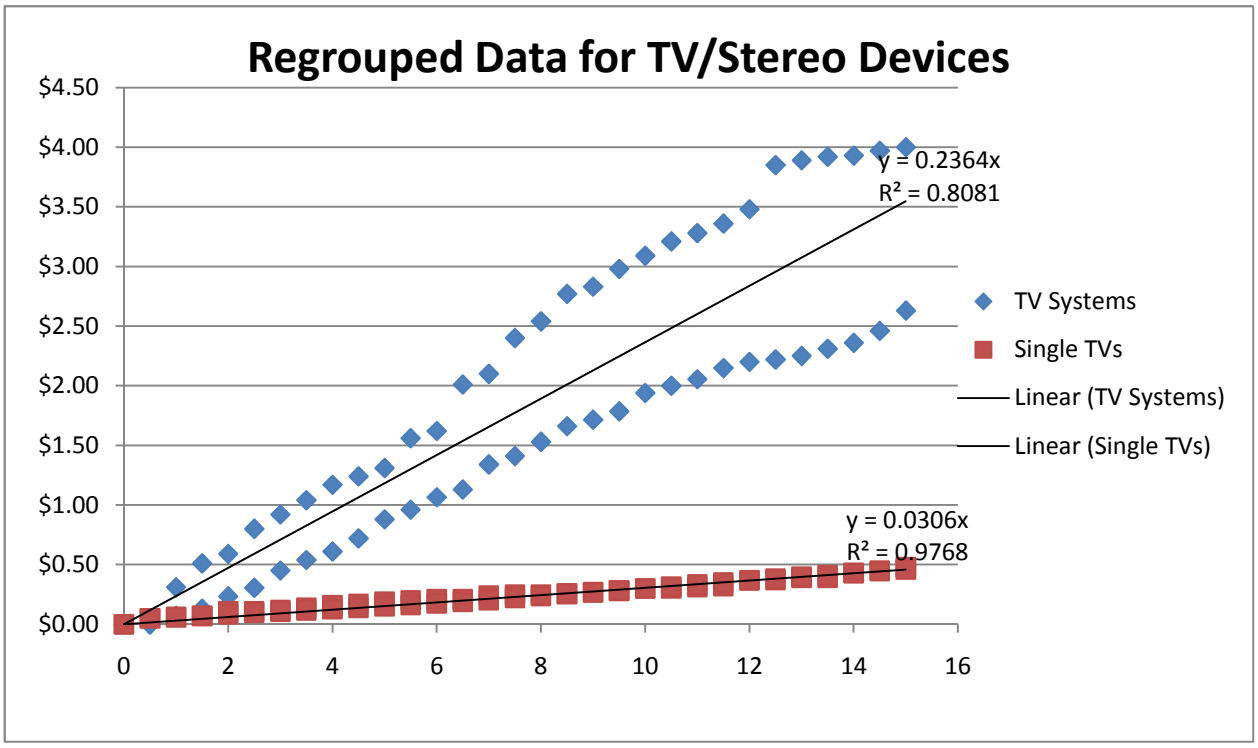
Graph 3: Shows the trendlines for each appliance used in the study.



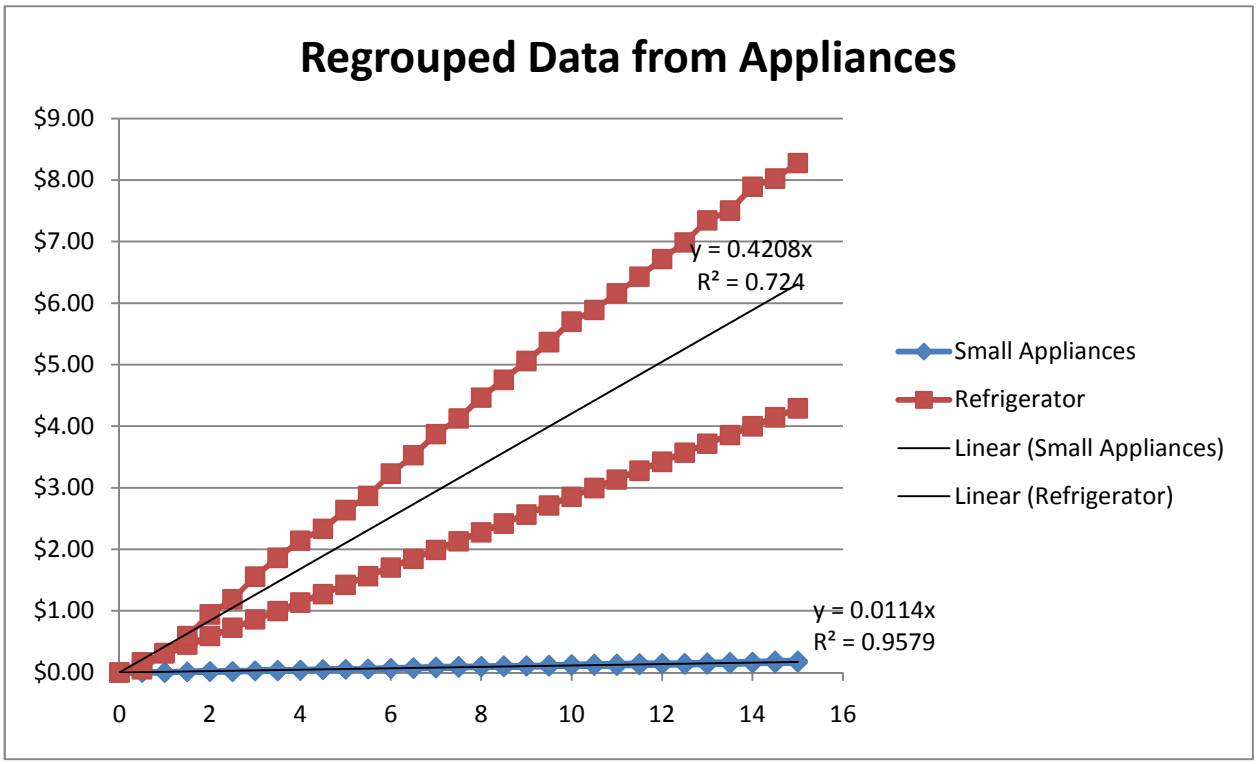
Graph 4: Shows trendlines for each computer tested.



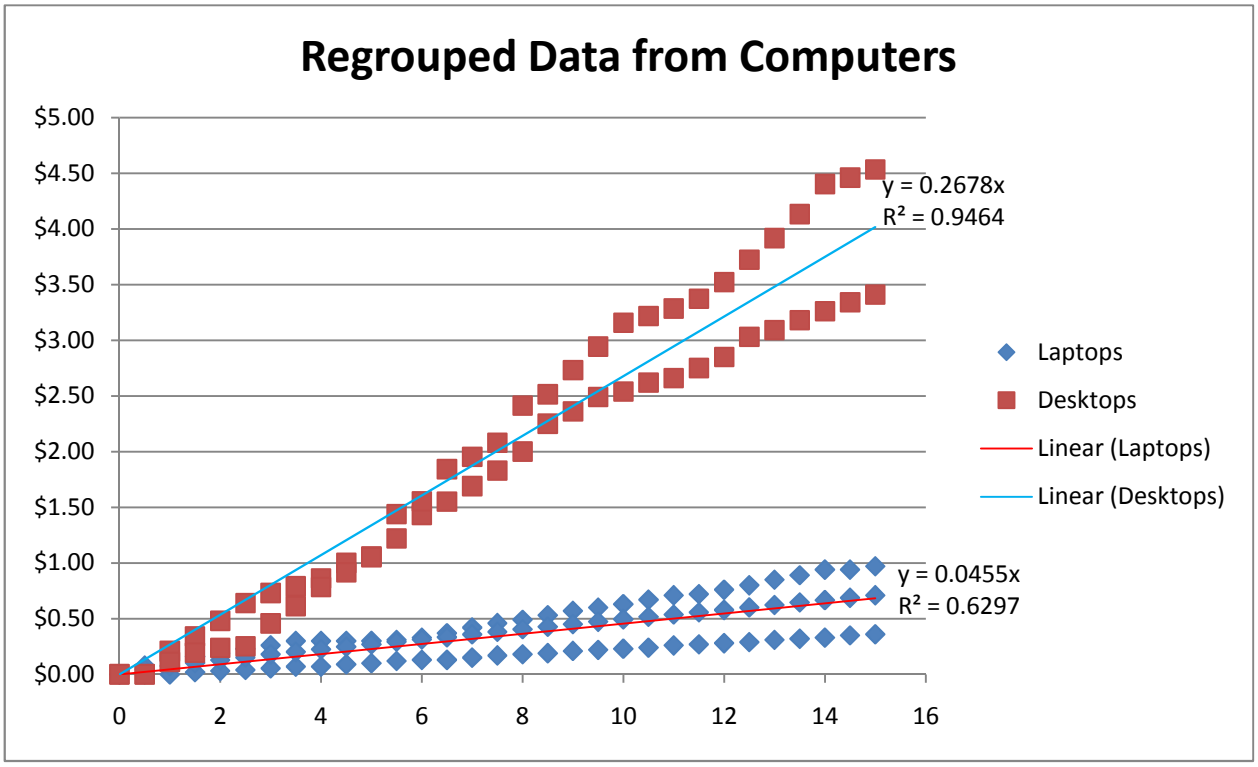
Graph 5: Shows the trendline for data taken with the Black and Decker Device.



Graph 6: Shows the trendlines for grouped television and entertainment systems used in the study.



Graph 7: Shows grouped data for each type of appliance tested.



Graph 8: Shows grouped data for computer usage based on computer type.

Table 1: Blank Usage Survey

Meter readings						
Date	**Time**	**Watts Up**	**Black & Decker**	**Kill a Watt 1**	**Kill a Watt 2**	**Kill a Watt 3**
2/21/2011						
2/21/2011						
2/22/2011						
2/22/2011						
2/23/2011						
2/23/2011						
2/24/2011						
2/24/2011						
2/25/2011						
2/25/2011						
2/26/2011						
2/26/2011						
2/27/2011						
2/27/2011						
2/28/2011						
2/28/2011						
3/1/2011						
3/1/2011						
3/2/2011						
3/2/2011						
3/3/2011						
3/3/2011						
3/4/2011						
3/4/2011						
3/5/2011						
3/5/2011						
3/6/2011						
3/6/2011						
3/7/2011						
3/7/2011						
***Take readings every morning and night at 9:00 or as close as possible, as long as times are consistent**						
***The Black and Decker is to monitor usage for the entire facility, all others are for single devices/plugs**						
***The 1st Kill-a-Watt should be used for a personal computer/laptop, the 2nd for television, and the 3rd for the refrigerator.**						
***The Watts Up Pro should be used for a stereo/music playing device.**						

Table 1 - Computer cost data

Date	Computer 1	Computer 2	Computer 3	Computer 4	Computer 5
2/21/2011	$0.00	$0.08	$0.05	$0.00	$0.00
2/21/2011	$0.00	$0.12	$0.08	$0.21	$0.11
2/22/2011	$0.02	$0.16	$0.10	$0.34	$0.20
2/22/2011	$0.03	$0.19	$0.13	$0.48	$0.24
2/23/2011	$0.04	$0.23	$0.15	$0.64	$0.25
2/23/2011	$0.06	$0.26	$0.18	$0.73	$0.46
2/24/2011	$0.07	$0.30	$0.20	$0.79	$0.61
2/24/2011	$0.07	$0.30	$0.23	$0.86	$0.78
2/25/2011	$0.09	$0.30	$0.25	$1.00	$0.92
2/25/2011	$0.10	$0.30	$0.27	$1.06	$1.05
2/26/2011	$0.12	$0.31	$0.29	$1.22	$1.44
2/26/2011	$0.13	$0.33	$0.31	$1.43	$1.55
2/27/2011	$0.13	$0.37	$0.33	$1.55	$1.84
2/27/2011	$0.15	$0.42	$0.36	$1.69	$1.95
2/28/2011	$0.17	$0.46	$0.38	$1.83	$2.08
2/28/2011	$0.18	$0.49	$0.40	$2.00	$2.41
3/1/2011	$0.19	$0.53	$0.43	$2.25	$2.52
3/1/2011	$0.21	$0.57	$0.45	$2.36	$2.73
3/2/2011	$0.22	$0.60	$0.47	$2.49	$2.94
3/2/2011	$0.23	$0.63	$0.50	$2.54	$3.16
3/3/2011	$0.24	$0.67	$0.52	$2.62	$3.22
3/3/2011	$0.26	$0.71	$0.54	$2.66	$3.29
3/4/2011	$0.27	$0.72	$0.56	$2.75	$3.37
3/4/2011	$0.28	$0.76	$0.58	$2.85	$3.52
3/5/2011	$0.29	$0.80	$0.60	$3.03	$3.72
3/5/2011	$0.31	$0.85	$0.62	$3.09	$3.92
3/6/2011	$0.32	$0.89	$0.65	$3.18	$4.13
3/6/2011	$0.33	$0.94	$0.67	$3.26	$4.40
3/7/2011	$0.35	$0.94	$0.69	$3.34	$4.46
3/7/2011	$0.36	$0.97	$0.71	$3.41	$4.53

Table 2: Shows the cost per day over the data gathering period for each computer.

Table 2 - Appliance cost data

Date	Microwave	Toaster	Refrigerator	Toaster Oven	Refrigerator 2
2/21/2011	$0.00	$0.00	$0.17	$0.00	$0.05
2/21/2011	$0.00	$0.00	$0.31	$0.02	$0.32
2/22/2011	$0.01	$0.01	$0.45	$0.04	$0.59
2/22/2011	$0.01	$0.02	$0.59	$0.07	$0.94
2/23/2011	$0.01	$0.02	$0.73	$0.09	$1.19
2/23/2011	$0.02	$0.03	$0.86	$0.12	$1.56
2/24/2011	$0.02	$0.04	$1.00	$0.14	$1.86
2/24/2011	$0.03	$0.04	$1.13	$0.17	$2.14
2/25/2011	$0.04	$0.05	$1.27	$0.20	$2.33
2/25/2011	$0.05	$0.05	$1.42	$0.22	$2.64
2/26/2011	$0.05	$0.06	$1.56	$0.24	$2.87
2/26/2011	$0.06	$0.07	$1.71	$0.26	$3.23
2/27/2011	$0.06	$0.08	$1.85	$0.29	$3.53
2/27/2011	$0.07	$0.09	$1.99	$0.31	$3.87
2/28/2011	$0.08	$0.10	$2.13	$0.47	$4.13
2/28/2011	$0.09	$0.10	$2.28	$0.49	$4.46
3/1/2011	$0.09	$0.11	$2.42	$0.52	$4.75
3/1/2011	$0.10	$0.11	$2.56	$0.54	$5.06
3/2/2011	$0.10	$0.12	$2.71	$0.56	$5.37
3/2/2011	$0.11	$0.13	$2.85	$0.59	$5.70
3/3/2011	$0.11	$0.14	$3.00	$0.62	$5.89
3/3/2011	$0.11	$0.14	$3.14	$0.64	$6.16
3/4/2011	$0.12	$0.15	$3.28	$0.81	$6.43
3/4/2011	$0.13	$0.15	$3.42	$0.84	$6.72
3/5/2011	$0.13	$0.15	$3.57	$1.12	$6.99
3/5/2011	$0.13	$0.16	$3.72	$1.25	$7.35
3/6/2011	$0.14	$0.17	$3.86	$1.36	$7.50
3/6/2011	$0.15	$0.17	$4.00	$1.43	$7.89
3/7/2011	$0.15	$0.19	$4.14	$1.57	$8.02
3/7/2011	$0.16	$0.19	$4.29	$1.68	$8.28

Table 3: Shows the overall costs of small appliances during the data gathering period.

Table 3 - Lamp cost data

Date	Lamp 1	Lamp 2
2/21/2011	$0.00	$0.02
2/21/2011	$0.01	$0.02
2/22/2011	$0.01	$0.03
2/22/2011	$0.01	$0.06
2/23/2011	$0.01	$0.06
2/23/2011	$0.01	$0.07
2/24/2011	$0.02	$0.08
2/24/2011	$0.02	$0.08
2/25/2011	$0.02	$0.08
2/25/2011	$0.02	$0.08
2/26/2011	$0.02	$0.08
2/26/2011	$0.03	$0.08
2/27/2011	$0.03	$0.08
2/27/2011	$0.03	$0.08
2/28/2011	$0.03	$0.08
2/28/2011	$0.04	$0.08
3/1/2011	$0.04	$0.09
3/1/2011	$0.05	$0.12
3/2/2011	$0.05	$0.13
3/2/2011	$0.05	$0.13
3/3/2011	$0.05	$0.13
3/3/2011	$0.06	$0.13
3/4/2011	$0.06	$0.13
3/4/2011	$0.06	$0.15
3/5/2011	$0.06	$0.15
3/5/2011	$0.07	$0.18
3/6/2011	$0.07	$0.18
3/6/2011	$0.07	$0.21
3/7/2011	$0.07	$0.21
3/7/2011	$0.08	$0.22

Table 4: Shows the data gathered for household lamps during the data gathering period.

Table 4 - Television cost data

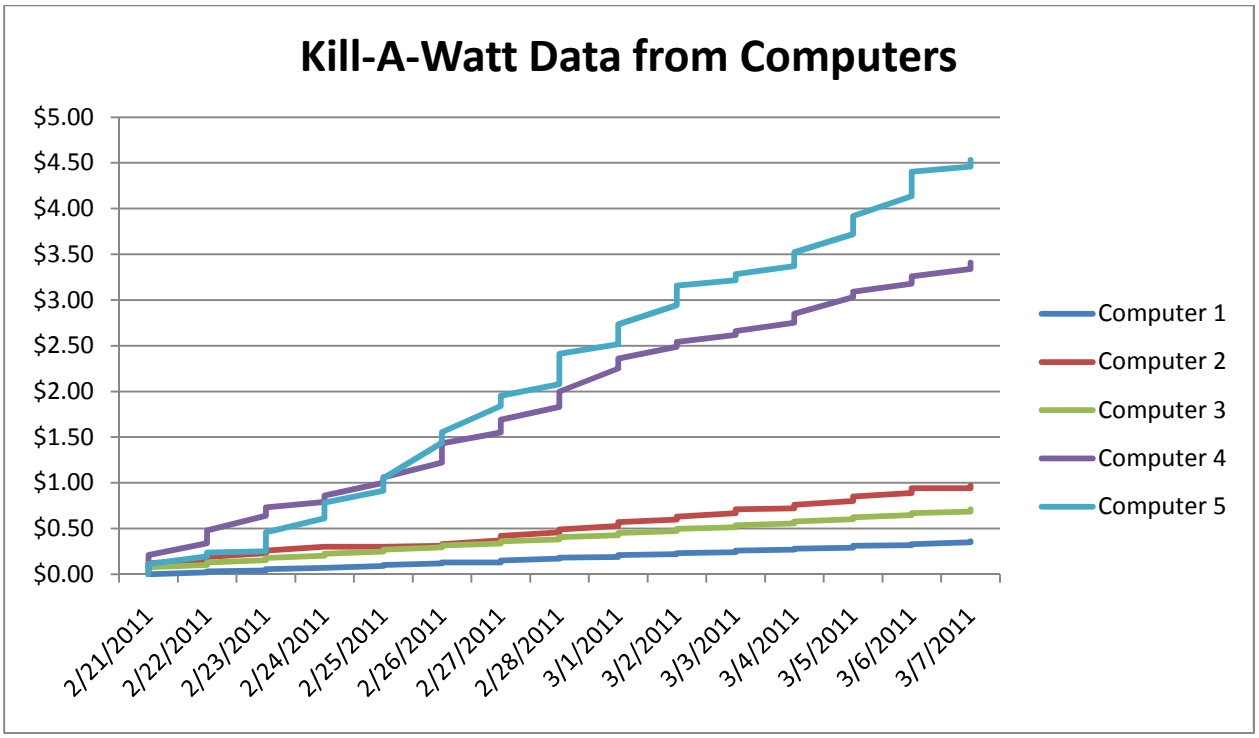
Date	TV & Stereo	TV 1	TV 2	TV 3	Stereo
2/21/2011	$0.00	$0.05	$0.05	$0.00	$0.00
2/21/2011	$0.07	$0.06	$0.06	$0.31	$0.00
2/22/2011	$0.13	$0.07	$0.07	$0.51	$0.00
2/22/2011	$0.23	$0.11	$0.08	$0.59	$0.00
2/23/2011	$0.31	$0.11	$0.10	$0.80	$0.03
2/23/2011	$0.45	$0.12	$0.11	$0.92	$0.03
2/24/2011	$0.54	$0.14	$0.12	$1.04	$0.03
2/24/2011	$0.61	$0.16	$0.13	$1.17	$0.03
2/25/2011	$0.72	$0.17	$0.14	$1.24	$0.06
2/25/2011	$0.88	$0.19	$0.15	$1.31	$0.06
2/26/2011	$0.96	$0.20	$0.16	$1.56	$0.06
2/26/2011	$1.07	$0.21	$0.17	$1.62	$0.09
2/27/2011	$1.13	$0.21	$0.19	$2.01	$0.15
2/27/2011	$1.34	$0.24	$0.20	$2.10	$0.18
2/28/2011	$1.41	$0.25	$0.22	$2.40	$0.18
2/28/2011	$1.53	$0.25	$0.24	$2.54	$0.24
3/1/2011	$1.66	$0.26	$0.25	$2.77	$0.24
3/1/2011	$1.72	$0.27	$0.27	$2.83	$0.24
3/2/2011	$1.79	$0.28	$0.28	$2.98	$0.27
3/2/2011	$1.94	$0.30	$0.30	$3.09	$0.27
3/3/2011	$2.00	$0.30	$0.32	$3.21	$0.27
3/3/2011	$2.06	$0.31	$0.33	$3.28	$0.30
3/4/2011	$2.15	$0.32	$0.35	$3.36	$0.30
3/4/2011	$2.20	$0.37	$0.37	$3.48	$0.30
3/5/2011	$2.22	$0.37	$0.38	$3.85	$0.30
3/5/2011	$2.25	$0.39	$0.40	$3.89	$0.33
3/6/2011	$2.31	$0.39	$0.41	$3.92	$0.33
3/6/2011	$2.36	$0.43	$0.43	$3.93	$0.33
3/7/2011	$2.46	$0.45	$0.44	$3.97	$0.36
3/7/2011	$2.63	$0.48	$0.46	$4.00	$0.36

Table 5: Watts Up Pro data gathered for home stereo and entertainment center configurations.

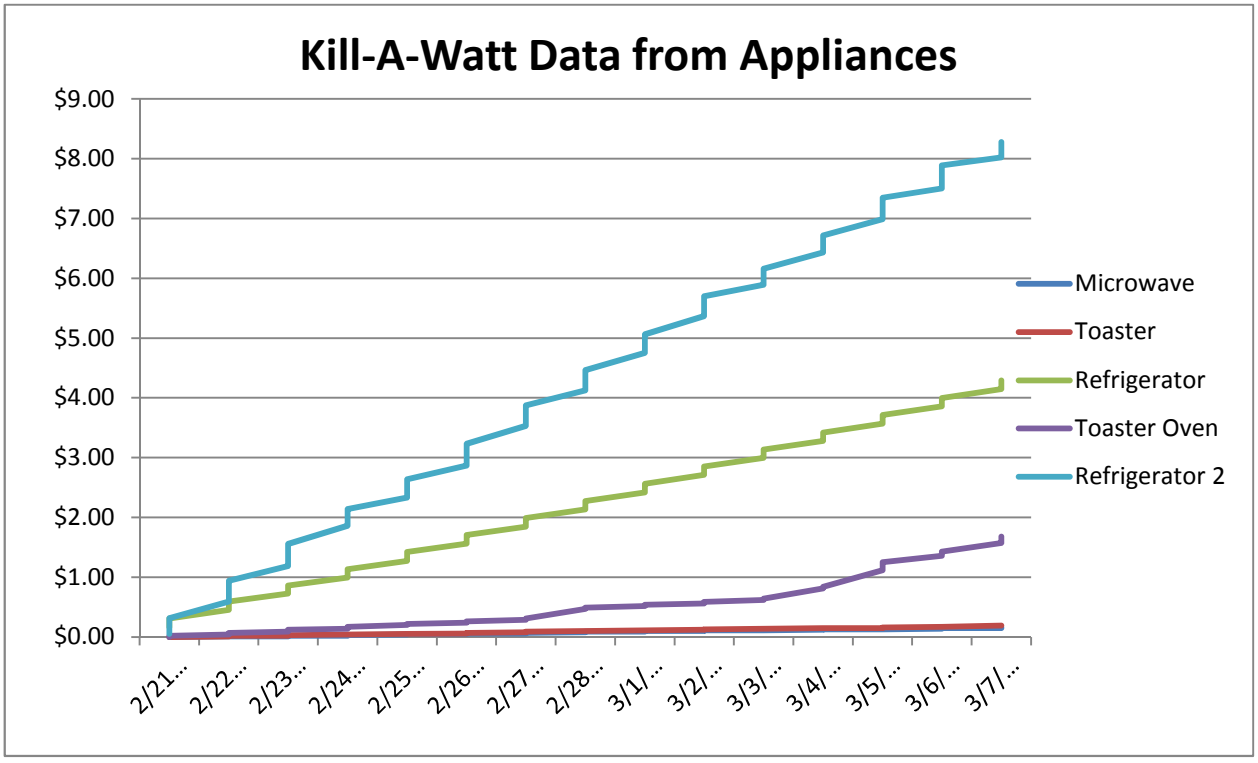
Table 5 - Black and Decker total home usage

Date	
2/21/2011	$0.00
2/21/2011	$1.84
2/22/2011	$3.41
2/22/2011	$4.11
2/23/2011	$5.78
2/23/2011	$6.65
2/24/2011	$7.18
2/24/2011	$7.61
2/25/2011	$8.49
2/25/2011	$10.15
2/26/2011	$11.46
2/26/2011	$12.60
2/27/2011	$13.30
2/27/2011	$13.83
2/28/2011	$14.35
2/28/2011	$14.88
3/1/2011	$16.10
3/1/2011	$17.06
3/2/2011	$18.46
3/2/2011	$19.08
3/3/2011	$20.13
3/3/2011	$20.91
3/4/2011	$21.79
3/4/2011	$22.23
3/5/2011	$22.93
3/5/2011	$23.63
3/6/2011	$24.76
3/6/2011	$26.95
3/7/2011	$29.04
3/7/2011	$31.11

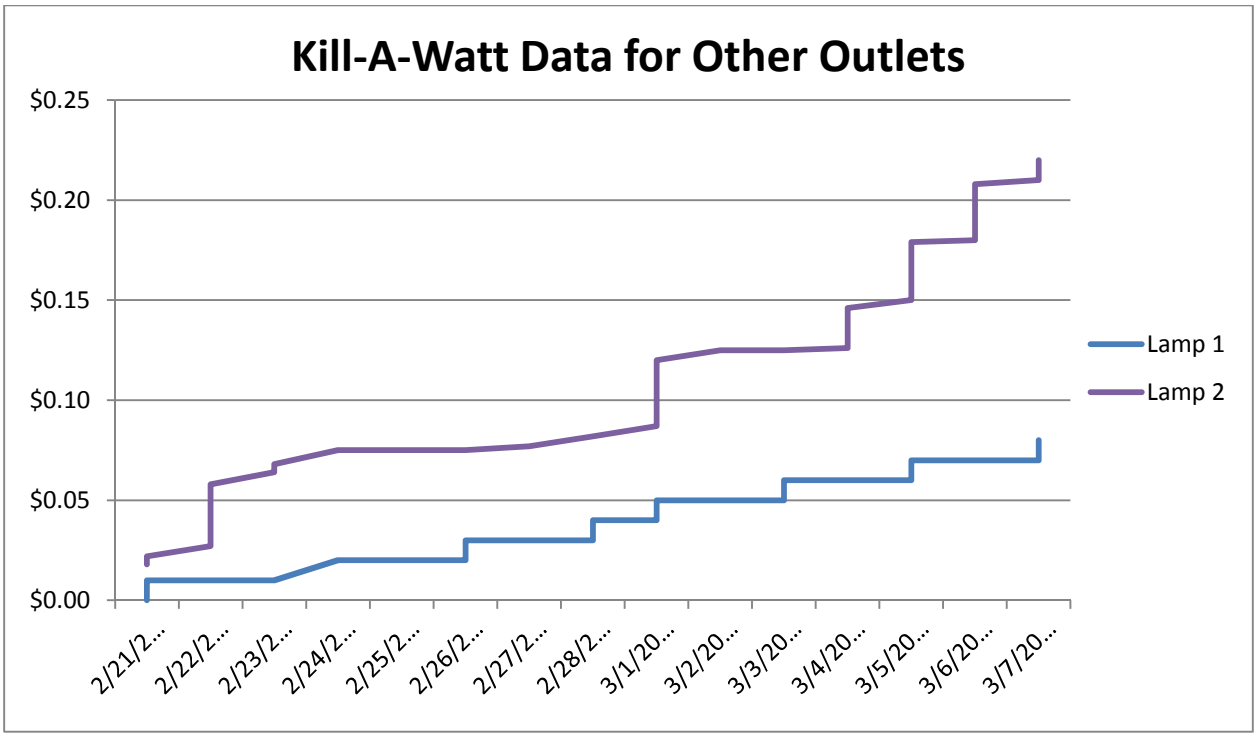
Table 6: Shows data for entire household taken with Black and Decker energy monitoring device over the data gathering period



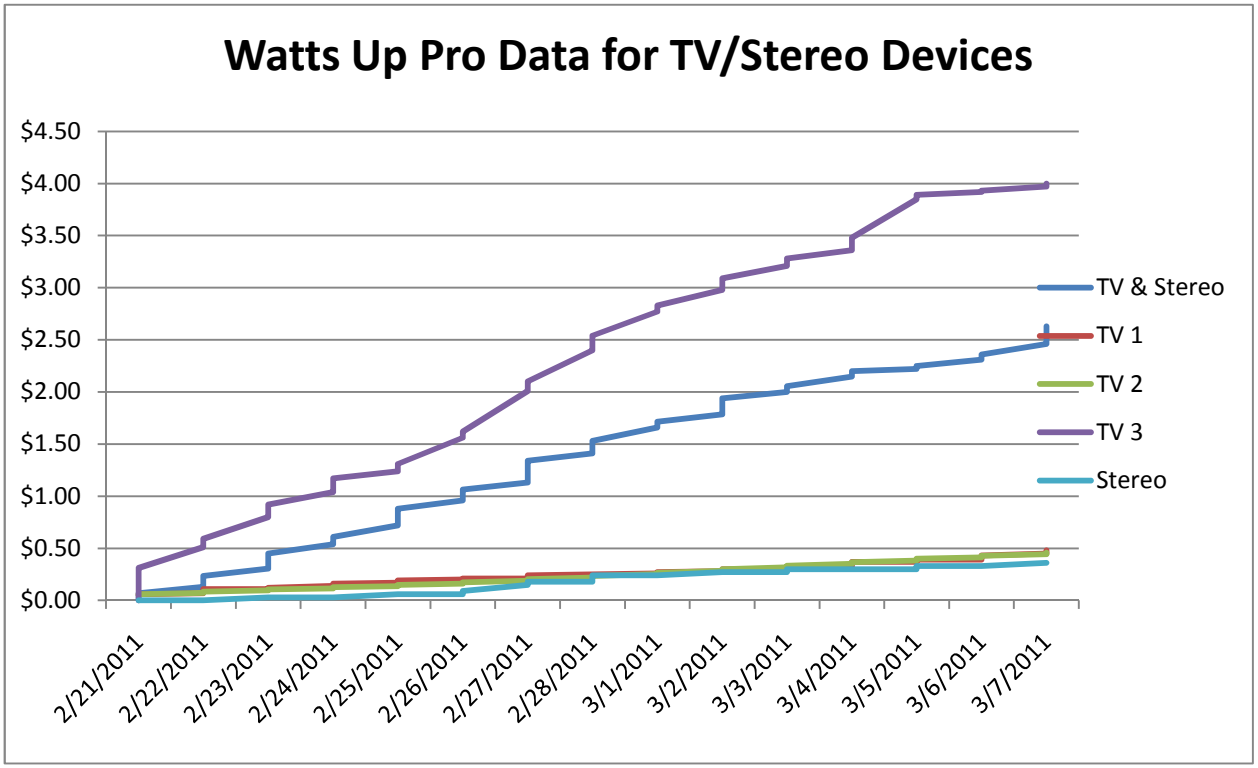
Graph 9: Shows the cost/time relationship of each computer.



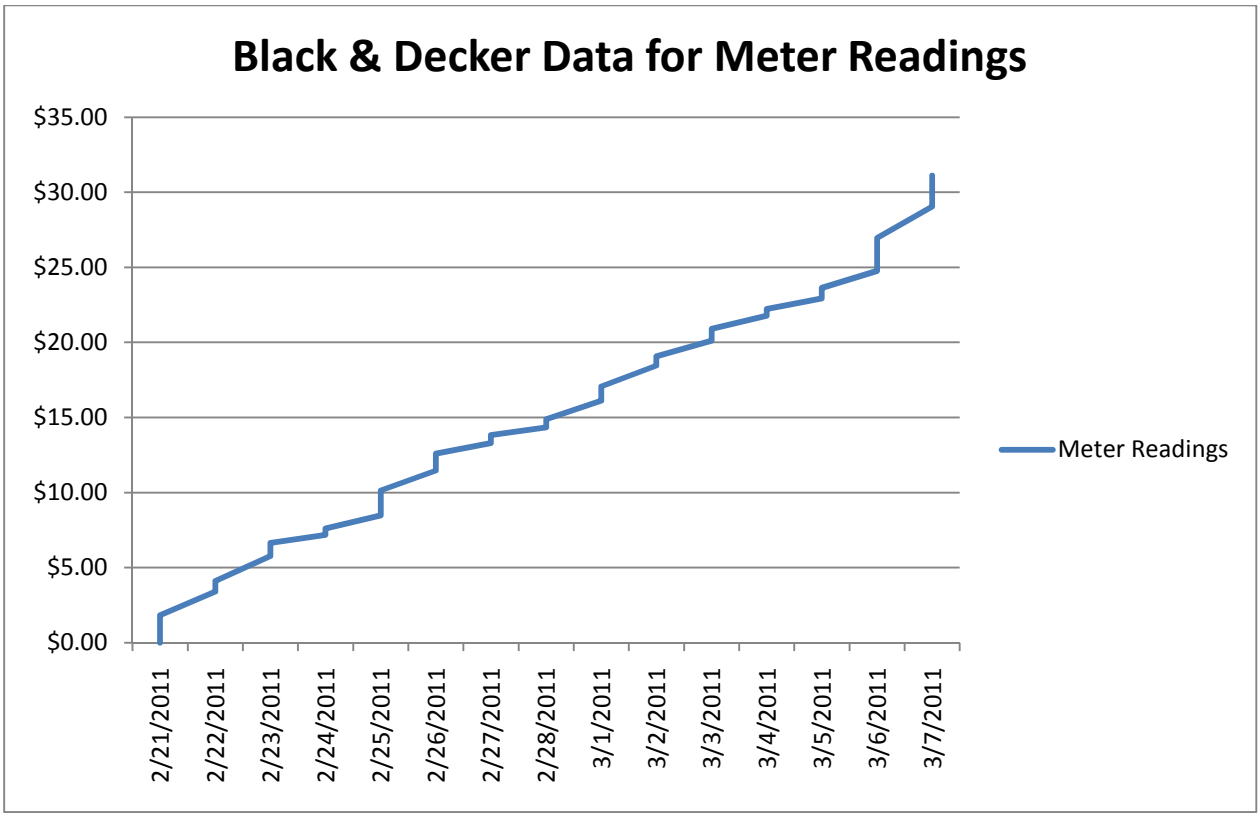
Graph 10: Shows the cost/time relationship of each appliance.



Graph 11: Shows cost/time relationship of lamps used during the study.



Graph 12: Shows the cost/time relationship of televisions used.



Graph 13: Shows the cost/time relationship using the Black and Decker meter for entire household.

Table 7 - Confidence Interval Calculation

Questions	Confidence Level	90%		N=	60
Work			1.65		
	Survey Result	Margin	Lower Limit	Upper Limit	
2	83.33%	7.94%	75.39%	91.27%	Leave computer on throughout day
3	50.00%	10.65%	39.35%	60.65%	Leave computer on at the end of the day
4	40.00%	10.44%	29.56%	50.44%	Do not turn off lights when leaving room
5	43.33%	10.56%	32.77%	53.89%	Do not charge devices at work
6	82.35%	8.12%	74.23%	90.47%	Of people that do bring devices to work, do so because of convenience
7	45.00%	10.60%	34.40%	55.60%	Have small appliance in office that require electricity
8	45.00%	10.60%	34.40%	55.60%	Consciously try to conserve energy at work
Home					
1	80.00%	8.52%	71.48%	88.52%	Receive bill from company (utilities not part of housing/renting fee)
2	88.33%	6.84%	81.49%	95.17%	Would be affected by provided a more detailed utility bill
3	76.67%	9.01%	67.66%	85.68%	Leave computer on during day
4	45.00%	10.60%	34.40%	55.60%	Turn computer off during day
5	100.00%	0.00%	100.00%	100.00%	Turn off lights when not in use
6	55.00%	10.60%	44.40%	65.60%	Use a mixture of light bulbs
7	83.33%	7.94%	75.39%	91.27%	Would be more likely to conserve energy by knowing real time costs/consumption
8	88.33%	6.84%	81.49%	95.17%	Would consciously shop for energy star appliances to save money
9	41.67%	10.50%	31.17%	52.17%	Consciously try to save money at home

Figure 1 - Blank Household and Work Surveys

Electricity Consumption and Usage - Home Environment
Exit this survey

1.

1. What type of household are you taking this survey for?

- ☐ What type of household are you taking this survey for? Home - 2,000 square feet or more
- ☐ Home - 1,000 -2,000 square feet
- ☐ Apartment
- ☐ College Dorm
- ☐ Duplex/Townhome

2. Do you receive a monthly statement from your electricity company?

- ☐ Do you receive a monthly statement from your electricity company? Yes
- ☐ No

3. Would you be more likely to read the statement in detail if it provided more information regarding your monthly usage? (Such as graphs displaying trends, ideas for saving money, etc.)

- ☐ Would you be more likely to read the statement in detail if it provided more information regarding your monthly usage? (Such as graphs displaying trends, ideas for saving money, etc.) Yes, very likely
- ☐ Yes, somewhat more likely
- ☐ No

4. Do you leave a computer on or charging during the day?

- ☐ Do you leave a computer on or charging during the day? Yes

☐ No

5. Do you turn your computer off at night?

☐ Do you turn your computer off at night? Yes

☐ No

6. Do you turn off lights when you are not using them?

☐ Do you turn off lights when you are not using them? Yes

☐ No

7. Do you use fluorescent bulbs or halogen bulbs?

☐ Do you use fluorescent bulbs or halogen bulbs? Fluorescent bulbs

☐ Halogen bulbs

☐ Incandescent bulbs

☐ Mixture

8. Would you be more likely to conserve energy if you knew how much various devices (such as TV's, dryers, microwaves, etc.) were consuming and the related cost in real time?

☐ Would you be more likely to conserve energy if you knew how much various devices (such as TV's, dryers, microwaves, etc.) were consuming and the related cost in real time? Yes

☐ No

☐ Somewhat

9. When buying new appliances, would you consciously shop for energy star appliances to help save money?

☐ When buying new appliances, would you consciously shop for energy star appliances to help save money? Yes

☐ No

10. Do you consciously try to conserve energy in your home by using other methods than listed within this survey?

☐ Do you consciously try to conserve energy in your home by using other methods than listed within this survey? Yes

☐ No

If yes, please describe how. 

Electricity Usage and Consumption - Work Environment
Exit this survey

1.

1. Are you taking this survey from a work environment during regular business hours?

☐ Are you taking this survey from a work environment during regular business hours? Yes

☐ No

2. What kind of company or organization do you work for?

☐ What kind of company or organization do you work for? Non-profit

☐ Manufacturing

☐ Sales

☐ Large Corporation

Other (please specify)

3. What type of work environment are you in?

- [ ] What type of work environment are you in? Personal office
- [ ] Cubicle

Other (please specify)

4. Do you have a tendency to leave your computer running throughout the day even if you are away from your desk?

- [ ] Do you have a tendency to leave your computer running throughout the day even if you are away from your desk? Yes
- [ ] No

5. Do you turn off your computer upon leaving the office for the day?

- [ ] Do you turn off your computer upon leaving the office for the day? Yes
- [ ] No

6. Do you turn off your office light when leaving the room during the day?

- [ ] Do you turn off your office light when leaving the room during the day? Yes
- [ ] No
- [ ] Automatically turned off

7. Do you ever bring other electronic devices from home to charge during the work day? (Such as IPOD's, cellphones, etc.)

- [ ] Do you ever bring other electronic devices from home to charge during the work day? (Such as IPOD's, cellphones, etc.) No
- [ ] Yes, Sometimes
- [ ] Yes, Frequently

8. If you answered yes to question 7, Do you charge these electronic devices at work for...

- [ ] If you answered yes to question 7, Do you charge these electronic devices at work for... Convenience
- [ ] To save money on your household utilities
- [ ] Not applicable

Other (please specify) 

9. Do you have small appliances in your office that require electricity to run? (Such as coffee makers, candle warmers, fans/heaters, etc.)

☐ Do you have small appliances in your office that require electricity to run? (Such as coffee makers, candle warmers, fans/heaters, etc.) Yes

☐ No

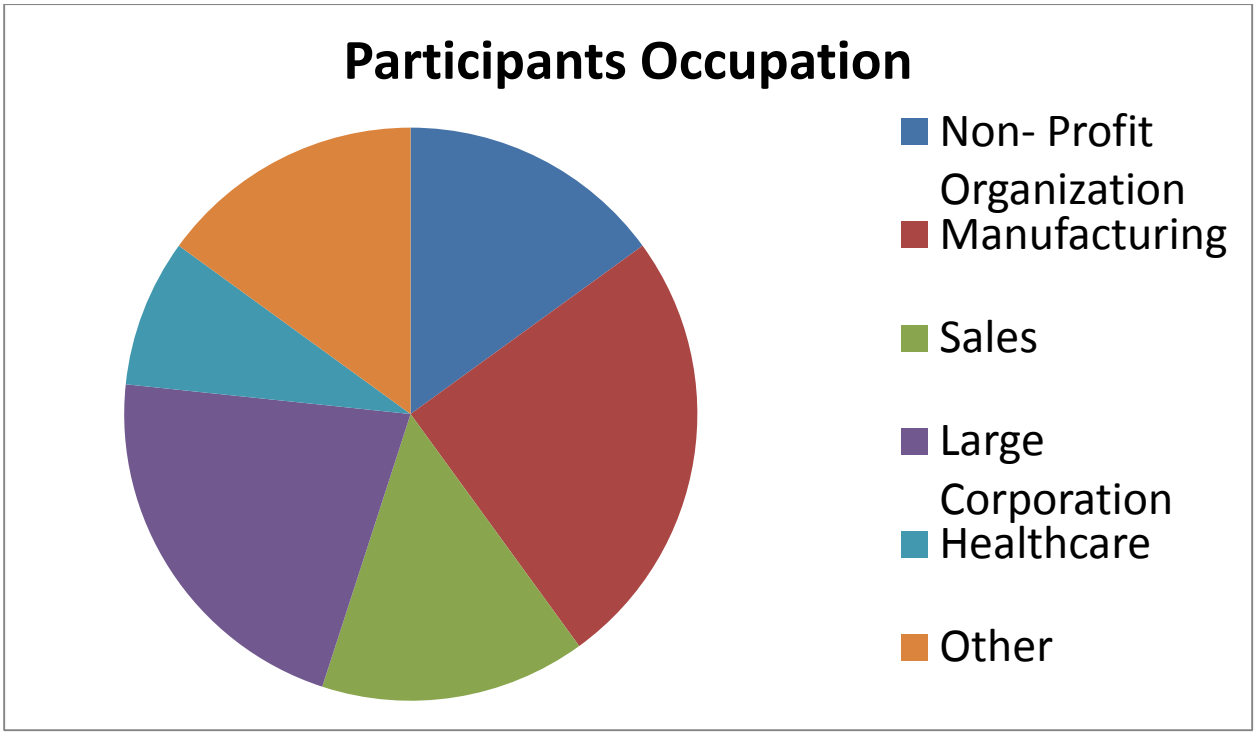
10. Do you consciously try to conserve energy/electricity at work?

☐ Do you consciously try to conserve energy/electricity at work? Yes

☐ No

If yes, please explain how.

Graph 14 - Work Survey Participant Occupation and Questions following

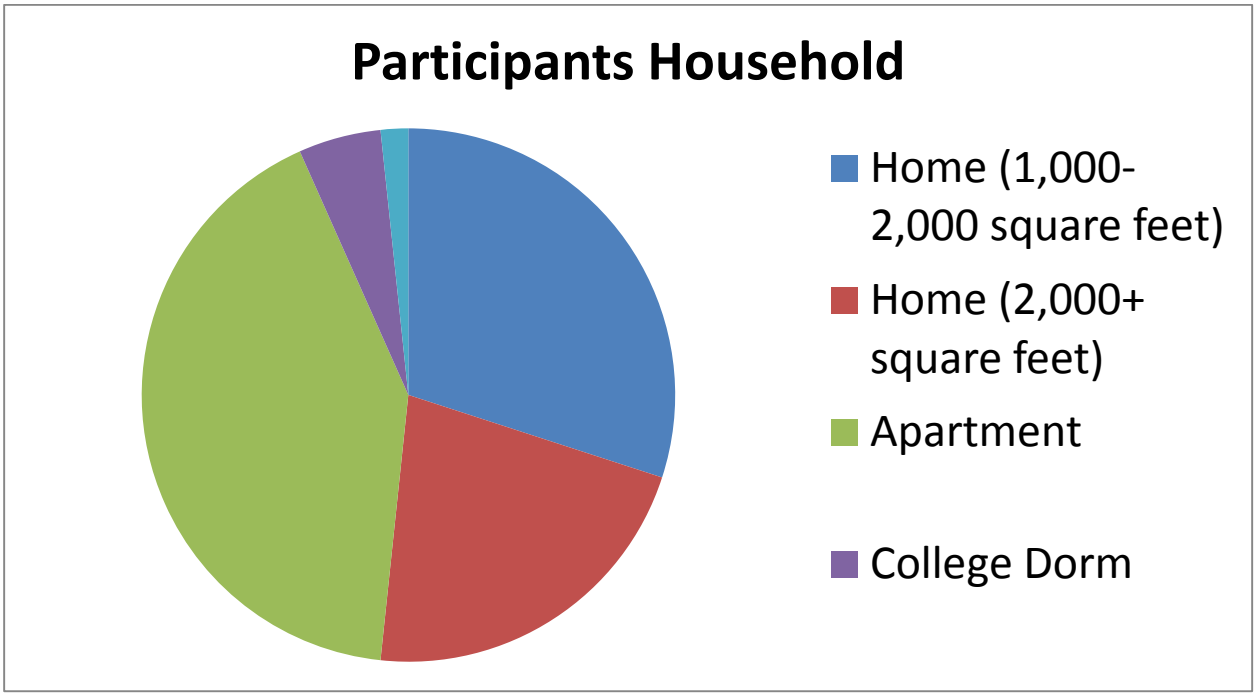


- Question 1: What type of work environment are you in?
  - Personal Office = 36.67%
  - Cubicle = 36.67%
  - Other = 26.66%
- Question 2: Do you leave your computer running throughout the day?
  - Yes = 83.33%
  - No = 16.67%
- Question 3: Do you turn your computer off when leaving the office for the day?
  - Yes = 50%
  - No = 50%

- Question 4: Do you turn your office lights off when you leave the room?
  - Yes = 43.33%
  - No = 40%
  - Automatically turns off = 16.67%
- Question 5: Do you ever bring other electronic devices from home to charge at work?
  - No = 43.33%
  - Yes, sometimes = 43.33%
  - Yes, frequently = 13.34%
- Question 6: Why?
  - Convenience = 46.67%
  - To save money on household electricity = 0%
  - N/A = 53.33%
- Question 7: Do you have small appliances in your office that require electricity to run?
  - Yes = 45%
  - No = 55%
- Question 8: Do you consciously try to save electricity at work?
  - Yes = 45%
  - No = 55%
  - Examples: turning off lights when not in use, hibernating computer when idle, shutting down computer when leaving
- Computer Usage
  - Most people leave computers on during the day
  - Half of them turn them off at the end of the day

- Lighting
    - More than half of people turn off lights when not in use
- Other Devices
    - More than half of people charge other devices at work for convenience
- Conserving Energy
    - More than half of people do NOT try to conserve energy at work

Graph 14 - Home Survey Participants and Type of Housing



- Question 1: Do you receive a bill from your local electricity company?
    - Yes = 80%
    - No = 20%

- Question 2: Would you be more likely to read the bill if it provided more detailed information regarding your monthly usage?
    - Yes, very likely = 45%
    - Yes, somewhat likely = 43.33%
    - No = 11.67%
- Question 3: Do you leave your computer on or charging during the day?
    - Yes = 76.67%
    - No = 23.33%
- Question 4: Do you turn your computer off during the night?
    - Yes = 45%
    - No = 55%
- Question 5: Do you turn off your lights when you are not using them?
    - Yes = 100%
    - No = 0%
- Question 6: What kind of light bulb do you use?
    - Fluorescent = 25%
    - Halogen = 13.33%
    - Incandescent = 6.67%
    - Mixture = 55%
- Question 7: Would you be more likely to conserve energy if you knew how much various devices were consuming and the related cost in real time?
    - Yes = 53.33%
    - Yes, somewhat = 30%
    - No = 16.67%

- Question 8: When buying new appliances, would you consciously shop for energy star appliances to help save money?
    - Yes = 88.3%
    - No = 11.7%
- Question 9: Do you consciously try to save money at home?
    - Yes = 41.67%
    - No = 58.33%
    - Examples: unplugging things when not in use, temperature regulation (HVAC and water heater)
- Billing
    - Most people receive a bill and would be more likely to read it if it provided more in-depth information
- Computer Usage
    - Most people leave computers on during the day and half turn them off at night
- Lighting
    - Most people use a mixture of bulbs and turn off lights when not in use
- Devices
    - Most people say they would be more conscious if they had devices to tell them how much certain devices where costing them
- Appliances
    - Most people would shop for energy star appliances
- Conservation